Art. XIII.—*Notes on the Dressing of Tin Ore.*

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During the past five years numerous tin-bearing lodes have been discovered in this and other Australasian colonies. The mines have been opened and expensive machinery erected, but the results in many instances have been disappointing to the investors. A great many samples of these ores have passed through my hands for assay and report, and I have come to the conclusion that, in part at any rate, the disappointment has been due to the want of a proper consideration of the question of how best to extract the ore from the gangue or associated mineral matter. This is especially the case where the gangue is a hard quartzose or granitic rock. According to the general custom, these ores are reduced to fine sand in the ordinary stamping battery, such as is used to reduce our auriferous ores. The latter, of course, require to be crushed very fine, so that the small particles of gold may be beaten out and separated from the quartz; but in the case of these tin ores this fine crushing reduces the brittle tin stone to a slime, while the hard tough rock with which it is associated is being converted into sand. With this result the separation of the tin ore becomes a matter of very great difficulty, for we have forgotten the cardinal principle of ore-dressing, which is, that the ore shall not be broken finer than is absolutely necessary to separate the rich mineral from the gangue or accompanying rock, and it would be well, I think, to remind those who are engaged in this work of the following general principles of ore-dressing:—

"1. Absolute perfection in separation according to specific gravity cannot be arrived at, chiefly on account of the irregularity of the various grains to be operated on.

"2. The more finely divided the stuff to be treated, the greater is the amount of labour and care required, and the more imperfect the separation.

"3. The reducing machinery may be considered the most perfect which produces the least quantity of stuff finer than that which it is intended to produce.

"4. It is necessary, in determining the degree of fineness to which a mineral should be reduced, to consider the metallurgical value of the ore contained in it, and set against this value the loss which will probably be incurred, together with the labour and expense attendant on the manipulation.

"5. The vein stuff should be reduced to such a degree of fineness that the largest proportion of 'deads' (worthless mineral) and clean ore should be obtained by the first operation, thus saving labour and preventing the loss incident to a finer subdivision of the ore and more extended treatment.

"6. The apparatus or plan of dressing may be considered the most efficient which, with stuff of a given size, allows at an equal cost the most perfect separation and of the proper separation of stuff of nearly equal specific gravity. The average percentage to which the clean ore is to be brought and the highest percentage to be allowed in the waste being determined, it is evident that the more perfect the degree of separation the greater will be the amount of clean ore and castaways (worthless mineral) obtained in each operation, and the quantities of middles or stuff to be reworked will be diminished.

"7. We may further consider a great improvement in dressing operations, such apparatus or plan of working as will allow, without a disproportionate increase in the cost, of the equally perfect separation of fine and coarse stuff. This will be of especial benefit in the case of finely disseminated ore, which is necessarily obliged to be 'reduced to a great degree of fineness.' Perhaps I should apologise for repeating the A B C of ore-dressing, but I fear that it has been forgotten by many, and that until it has been relearnt many good mines will continue to give poor returns."

The treatment I propose for these hard ores, which consist of very tough quartz, with more or less feldspar, mica, tourmaline, and tin stone, is (1) Calcination, in heaps or kilns; (2) crushing in an ore or stone-breaker; (3) disintegration; (4) classification of disintegrated ore by a series of sieves; (5) concentration of the classified ore.

I can, perhaps, best illustrate the success of this treatment by giving the actual results obtained from a quantity (about half a ton) of very hard ore from the Ben Lomond district, Tasmania, kindly given for the trial by Mr. J. E. Dobson, at my suggestion, and in the interest of Mr. C. W.

Chapman, of Hobart. The work of calcining, crushing, and disintegration was conducted under the immediate supervision of Mr. Rees Davis, the well-known engineer.

The stone was calcined, without previous breaking, in a kiln belonging to the Victorian Patent Freestone Company, and was found to be rendered very friable; even the finest ore could be easily separated from the quartz and other minerals. The ore was then passed through one of Hope's stone-breakers, at the rate of about half a ton in rather less than five minutes.

The result of this was—

	Class in p. c.	P. c. of Tin Ore found.	P. c. of free Tin Ore in Sand under $\frac{1}{4}$-in. diameter.
1. Coarse, roughly-broken Ore	56·0	... —	... —
2. $\frac{1}{4}$ to $\frac{1}{10}$-in. in diameter	22·0	... 4·28	... 2·04
3. $\frac{1}{10}$ „ $\frac{1}{20}$ „ „	15·5	... 13·77	... 4·95
4. $\frac{1}{20}$ „ $\frac{1}{40}$ „ „	2·5	... 29·7	... 1·78
5. $\frac{1}{40}$ „ $\frac{1}{60}$ „ „	2·5	... 39·5	... 2·37
6. less than $\frac{1}{60}$-in. „	1·5	... 37·0	... 1·84
			12·98

This 12·98 per cent. of clean tin ore gave on assay 69 per cent. of pure tin, which would be equal to 8·99 per cent. on the ore reduced to less than $\frac{1}{4}$-in. in diameter.

Owing to the want of suitable sieves, the whole of the ore from the stone-breaker was sent to the disintegrator, instead of sending only those portions, Nos. 1 and 2, which contain attached or enclosed tin ore.

The disintegrator used was one made by Mr. Buncle as a bark mill. The rate of disintegration was as nearly as possible 1 cwt. of ore per minute, but even this rate and the time taken by Mr. Hope's stone-crusher is only approximate; the feeding was done by hand from bags, and was irregular. With a proper regular feed the work would be done with much greater rapidity.

From the disintegrator we obtained the following sizes of material:—

Grains over $\frac{1}{10}$ of an inch in diameter	...	13·5	per cent.
Between $\frac{1}{10}$ and $\frac{1}{20}$ „ „	...	30·0	„
„ $\frac{1}{20}$ „ $\frac{1}{30}$ „ „	...	14·0	„
„ $\frac{1}{30}$ „ $\frac{1}{50}$ „ „	...	18·5	„
„ $\frac{1}{50}$ „ $\frac{1}{100}$ „ „	...	11·0	„
Less than $\frac{1}{100}$ „ „	...	13·0	„

Mr. J. L. Morley washed (without further crushing) a

portion of each of these classes, and obtained the free tin ore, which he smelted, and has given me the following table of results :—

Mesh of Sieve holding ore.	Per cent. of class.	Per cent. of tin in each class.	Per cent. of tin on the whole ore.	Per cent. of return of tin in each class.
$\frac{1}{10}$ inch	13·5	*none, nearly all quartz*		
$\frac{1}{20}$ "	30·0	3·81	1·14	10·40
$\frac{1}{30}$ "	14·0	9·65	1·35	12·30
$\frac{1}{50}$ "	18·5	18·9	3·52	32·05
$\frac{1}{100}$ "	11·0	23·62	2·57	23·40
Ore passing thro' $\frac{1}{100}$ inch	13·0	18·9	2·40	21·85
	100·0		10·98	100·00

These results show that in this operation we can at once get rid of 13·5 per cent. of worthless material, while we are classifying the remainder into grades of equal-sized grains, from which the clean tin ore may be separated with ease by any of the washing processes. I should mention that the average assay of this ore made by my assistant, Mr. Adams, was 11 per cent. of tin, so that Mr. Morley's return of 10·98 per cent. of tin shows the separation to have been almost perfect.

This process is not suited to clayey ores, or ores associated with hydrous minerals, such as brown iron ore, but with quartzose or granitic ores I have no doubt that when compared with the results of the ordinary crushing and dressing plants it will be found to return much more and better dressed ore for the smelter, a higher yield of metal, smaller requirements in space for machinery, less washing water, and lower working cost.

The ore classified by the sieves may be treated by dry concentrators, a point of some moment in many districts where water is scarce, or has to be brought long distances.